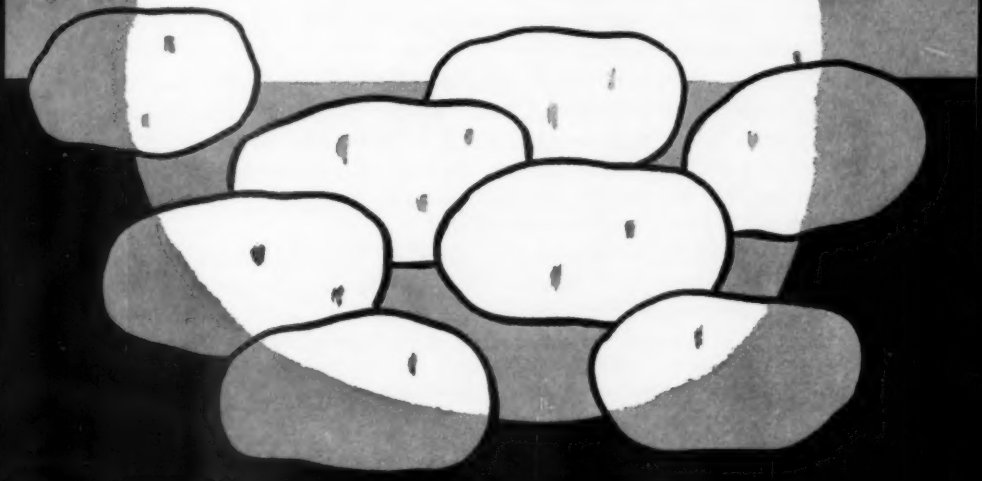
POTATO GREENING UNDER ARTIFICIAL LIGHT

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CORNELL EXTENSION BULLETIN 1033
NEW YORK STATE COLLEGE OF AGRICULTURE

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LIGHTBURN or surface greening is a condition occurring in potatoes that have been exposed to natural or artificial light. This condition is legally defined as, "Greening caused by exposure to natural or artificial light when the appearance of the individual potato is materially affected by yellowish or greenish surface discoloration, or when the discoloration extends into the flesh of the potato and cannot be removed without the loss of more than five percent of the total weight of the potato including the peel covering the defective area".[1] In the case of "serious damage,"[2] the total loss may not be more than ten percent. In permitting this condition to occur, the retailer not only lessens the attractiveness of his potatoes, but incurs the risk of legal action by regulatory authorities enforcing grade standards.

In judging the amount of greening that has occurred in potatoes, two things must be observed and determined. One is whether the greening is just beginning or whether it has progressed far enough to throw the pototaes out of their specified grade. The second factor is the depth of the green color in the skin. Greening that has occurred over a considerable period of time is of greater depth and its removal requires a thicker peel.

In the white-skinned varieties of potatoes, the lightburned condition usually is detectable very early. It develops through a series of stages from a yellowish cast to a definite green. The amount of greening developed is dependent upon the length of exposure and the intensity of the light on the potatoes. It is an

[1] *U.S. Standards for Potatoes*, Section 15.1554, (c) July 15, 1958.
[2] *Ibid.* Section 15.1556, (c).

appearance defect and in the white-skinned varieties it is often not necessary for an inspector to cut potatoes to determine that they will be out of U.S. No. 1 grade; appearance alone is sufficient. The color plates in the supplement to this bulletin show several stages of the greening condition in white-skinned varieties. Plate 1 shows normal skin color for white-skinned potatoes. Plate 2 shows potatoes that have had some exposure to light. An inspector probably would cut such potatoes to determine the depth of greening in the flesh. Plate 3 shows the color of potatoes that would not meet U.S. No. 1 grade standards on the basis of appearance alone. Plate 4 shows the color of white-skinned varieties that definitely would not meet grade standards.

The yellowish to greenish coloring in the potato skin is harmless since it is chlorophyll, the common pigment of green plants. It is found in abundance in lettuce and other green vegetables. Its presence in potatoes is considered undesirable, however, because at times another compound called solanine is formed with the chlorophyll. This latter material, solanine, is said to cause potatoes to have a bitter or undesirable flavor. Pure crystals of solanine are bitter. Light is not essential for the formation of solanine, but it usually is found in greater amounts in those areas of the potato where biological activity is greatest. When potatoes sprout, the solanine content increases greatly in the surface area immediately around the eye, while the sprouts themselves may have five times the concentration of solanine as is found in the tuber. Likewise the formation of chlorophyll under the influence of light indicates an increased biological activity, so solanine may be expected to increase also. There are no visible methods of determining the amount of solanine in any potato tuber, only chemical methods. The amount of greening or chlorophyll found in a potato, therefore, is in no way a measure of its solanine content.

The amount of greening that can occur depends upon the variety and the age of the potatoes. New thin-skinned potatoes may green twice as fast as the same potatoes kept in storage several months. However, old potatoes from storage that have started to sprout may be quite high in solanine content, and still not green badly. It is a general rule, however, that where greening is visible, there is likely to be an increased amount of solanine.

Factors That Influence Greening

A number of factors influence the production of both chlorophyll and solanine in potato tubers. The more important ones from the retailers point of view are: (1) type of potato, (2) variety, (3) intensity of light on displays, and (4) duration of light on displays.

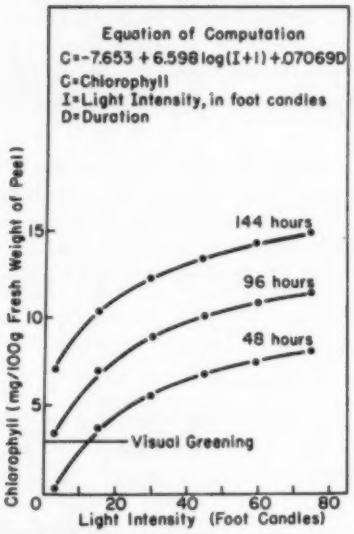
There are three types of potatoes regularly merchandised by retailers. These are the smooth white-skinned, the smooth red-skinned and the russet-skinned

types. The Katahdin is a good example of a smooth white-skinned variety, the Red Pontiac of a smooth red-skinned variety, and the Russet Burbank of a russeted variety. In chemical tests it has been shown that the Katahdin and the Red Pontiac have about the same amount of greening under similar conditions of light intensity, but to the naked eye, the white-skinned Katahdin appeared to be more heavily greened. The red color of the Pontiac tended to mask the visual symptoms. Russet Burbanks also appeared not to green as heavily as Katahdin, but in this case it is the russeting that masks the chlorophyll. A slight scratch will generally reveal the green color below the surface.

Different varieties of potatoes of the same type frequently do not lightburn equally when exposed to the same kind of light conditions. By reputation, Kennebec, a smooth-skinned variety, is one that greens badly. This was borne out in tests when, in two years out of three, Kennebec and Cherokee greened twice as much as Katahdin. Other smooth-skinned varieties undoubtedly behave differently also. Since these differences are known to exist, the retailer can perform his own simple tests of varieties under his own lighting conditions by exposing tubers for known periods of time and comparing them with each other and with a sample from the same lot or variety that has been kept in complete darkness.

FIGURE 1[2]

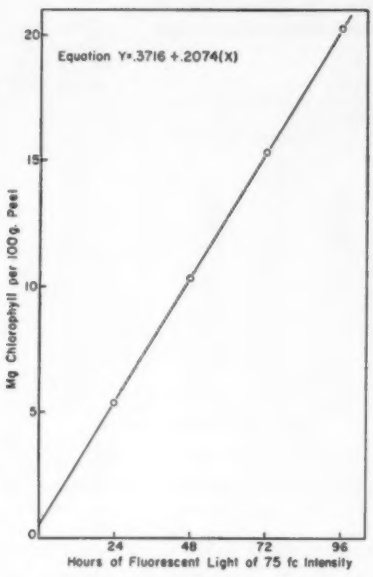
Chlorophyll Development in Potatoes under Artificial Light



The amount of greening that can occur to potato tubers in a display is dependent upon two factors, (1) the intensity of the light hitting the exposed tubers and, (2) the length of time of the exposure. Figure 1 illustrates the results of an experiment in which Russet Burbank potatoes were exposed to five intensities of fluorescent light for three periods of 48, 96, and 144 hours. The amount of chlorophyll was measured by extracting it from 100 grams of peel; 100 grams of peel is about the amount of peel ordinarily cut from six average sized potatoes. When the naked eye can first detect the appearance of green color in a potato the chlorophyll is

[2]Data from unpublished thesis, *Chlorophyll and Solanine Development in Potato Tubers Exposed to Fluorescent Lights*, by Dwain D. Gull, Cornell University, Ithaca, New York, 1959.

FIGURE 2[4]



The amount of chlorophyll extracted from Kennebec potatoes exposed to 75 foot-candles of fluorescent light for various lengths of time.

around three milligrams per 100 grams of peel. It can be seen from these curves that considerable greening can occur on potatoes in a relatively dark back room if they are exposed to some light and are left for any length of time. Figure 2 shows the results of another test with Kennebec potatoes exposed to 75 foot-candles of fluorescent light for various lengths of time. It can be seen from this graph that the amount of greening is directly proportional to the length of exposure.

Lightburn on potatoes was not a problem until very recent years. In the past, stores were not highly illuminated, the potatoes were not washed and often were sold in kraft paper bags. Modern supermarkets have large numbers of fluorescent lights, and frequently the walls are painted in white or very light colors so that there are many reflective surfaces. In a survey of 85 stores of all types in New York State, 107 potato displays were checked for light incidence. Light incidence was found to range from 5 to 375 foot-candles. Sixty percent of these displays had light incidence between 20 and 60 foot-candles. In this range exposed tubers are quickly lightburned.

The most accurate way to determine light intensity is with a foot-candle meter. An instrument of this kind is usually not available in a retail store or chain, but the sales engineer for the local light company usually has such an instrument, and can furnish readings in several locations within a store in a few minutes. An approximation of the probable light intensity on a display or area can be determined from the data in Tables 1 and 2. Table 1 gives approximate foot-candle values directly below an ordinary one- or two-bank 40-watt fluorescent light for distances up to 15 feet. Table 2 gives the approximate foot-candle values directly below 30-watt fluorescent lights for white, daylight and several colors of tubes. These values are only approximate because reflective surfaces

[4]Data from article by Dwain D. Gull and F. M. Isenberg, "Lightburn and Off-flavor Development in Potato Tubers Exposed to Fluorescent Lights," *Proceedings of the American Society of Horticultural Science*, Volume 71, pages 446-454, 1958.

TABLE 1

Approximate Foot-candle Value of Fluorescent Lights at Various Distances Directly Below the Source

Distance in Feet	Two Tube 40 watt-white	One Tube 40 watt-white
	Foot-candles	*Foot-candles*
1	500	280
2	225	122
3	225	68
4	75	42
5	52	29
6	38	20
7	28	17
8	22	12
9	18	9
10	15	8
11	12	7
12	10	6
13	9	5
14	8	4
15	7	3

such as mirrors, white panels, or other architectural features may increase or decrease these values slightly.

Even under present conditions of high illumination in stores, the kraft paper bag offers very good protection against lightburn. However, the present day customer is educated to buying washed produce in film packages, and expects potatoes to be merchandised in this manner. Long years of experience with closed kraft bags has not enhanced their reputation with many customers, and it must be admitted that the bag was used often to hide defects that would not pass in film bags today. Some suppliers have offered specially colored film bags for potatoes which are supposed to reduce lightburn.

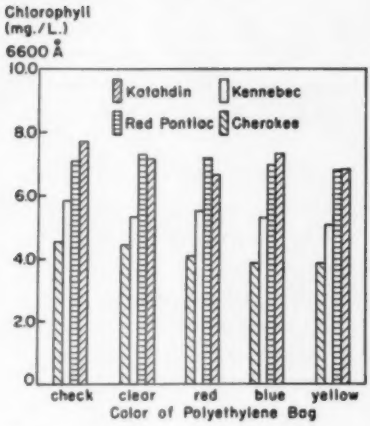
Many tests with these bags have indicated that they are effective only if the light intensity in which they are displayed is low. Most bags are 1.5 to 2 mils

TABLE 2

Approximate Foot-candle Value of Single Tube 30-Watt Fluorescent Lights at Various Distances Directly Below the Source

Distance in Feet	White	Daylight	Blue	Green	Pink	Gold
1	170	170	100	290	88	148
2	80	80	48	135	41	72
3	45	45	30	80	25	42
4	33	33	20	54	18	42

FIGURE 3[5]



The development of chlorophyll in four varieties of potatoes when exposed to fluorescent light for 60 hours at 75 foot-candles, in red, blue, yellow and clear polethylene bags.

in thickness, and films of this thickness when exposed to some of the high light intensities found in the present day markets, transmit enough light to cause as much lightburn as the clear films. The loss in visibility through colored films is more detrimental to the sale of potatoes than the protection against lightburn is worth. Figure 3 shows the results of one test using clear, red, blue and yellow film bags with four different potato varieties. In 75 foot-candles of light for 60 hours, there was little practical difference between the films, and none of the films reduced the greening much below the check which had no bag at all. The red and blue films in this test reduced the amount of light reaching the tubers by 25 foot-candles, but unfortunately red and blue light are the most efficient kinds of light for producing chlorophyll.

In another test exposing potatoes to six kinds of fluorescent tubes, gold, green, white, daylight, pink, and blue at two intensities of 25 and 75 foot-candles, the daylight tube was most effective at 25 foot-candles in reducing chlorophyll production, and the gold tube at 75 foot-candles. Pink and blue tubes produced the most chlorophyll at both intensities.

Things To Do For Control of Lightburn in Potatoes

1. Watch potato displays carefully for signs of greening. Sometimes potatoes have had considerable light exposure before being received in the store, and with little additional light will green rapidly. When it is apparent that a lot of potatoes in bulk or polyethylene are going to green more rapidly than sales will remove them from the store, it is better to bag them in closed kraft bags than have the lot condemned.

2. Displays of potatoes in bulk or packaged in films should be located in a part of the store where the light intensity is lowest. If in doubt about light

[5]Data from article by Dwain D. Gull and F. M. Isenberg, "Lightburn and Off-flavor Development in Potato Tubers Exposed to Fluorescent Lights," *Proceedings of the American Society of Horticultural Science*, Volume 71, pages 446-454, 1958.

intensities, ask the sales engineer of the local light company to furnish a light meter and conduct this sort of test. Approximations of light intensities for fluorescent lights can be made from the data in Tables 1 and 2 of this bulletin.

3. Never locate displays on sidewalks or in front windows, especially if the potatoes are packaged in polyethylene or window bags. All displays should be accessible to customers at all times so that potatoes move through the displays within three days.

4. Do not spotlight displays of bulk potatoes, film bags or window bags.

5. Where ceiling lights are of a uniformly high intensity throughout the merchandising area, a canopy or decorative cover may be erected to cut direct rays of light and afford potatoes some protection.

6. Keep reserve stocks in darkened areas of the backroom. Potatoes in burlap should be covered with more empty bags or a canvas cover if stored in a room where light is necessary. Burlap is a very coarse material and transmits light readily. Film bags of potatoes should be kept in master containers until ready for displaying.

7. If possible, check with your supplier or warehouse to see how they handle potatoes. They may not know how serious a problem lightburn is for the retailer. Burlap sacked potatoes are often left on streets or docks in the sun for a considerable time. This treatment may start the greening reaction that becomes noticeable on the retailers counter.

8. Additional information about potatoes may be obtained by writing to your College of Agriculture, your State Department of Agriculture and Markets, or to the United States Department of Agriculture in Washington, D.C.

A publication of the
New York State College of Agriculture,
a unit of the State University of New York,
at Cornell University,
Ithaca, New York

JUNE 1959

Cooperative Extension Service, New York State College of Agriculture at Cornell University and the U. S. Department of Agriculture cooperating. In furtherance of Acts of Congress May 8, June 30, 1914. M. C. Bond, Director of Extension, Ithaca, New York.

PS—10M